RAS band from MSS systems concerning the proposed rules. It is assumed that the rule modifications proposed by CORF will alleviate Cornell's concerns However, a major radioastronomy concern has not even been addressed -- protection of the passive use of the 1610 - 1667 MHz band. Cornell stated:[6]

> *The proposed scheme of using downlinks in the MSS band will surely affect radio astronomical research in a large fraction of the redshifted OH band. Current coordination efforts for the Glonass/Glonass-M system may help significantly reduce and shift the downlink transmissions of Glonass-M. A downlink in the MSS band can have the same disastrous effects on extragalactic OH research as Glonass had before.*

It further states:

> *Cornell and the Observatory want to go on record that the allocation of an MSS downlink in the 1610 - 1626.5 MHz band can close another valuable window to the Universe. Future expansion of the downlink frequency allocation in order to accommodate the need for spectrum of an undoubtedly successful first generation system could close this window even further.*

LQP agrees with these comments by Cornell University and the Arecibo Observatory on not increasing the presently allocated 5.15 MHz for satellite secondary downlink operations since it would further restrict the spectrum available for observations and also since there would be a corresponding increase in the uplink allocation to TDMA MSS systems.

2.1.2 Reply to Comments of Motorola

LQP takes exception to the first sentence of the Motorola proposal in the NPRM Comments (pp. 54-55) to modify the Commission's proposed Rule 25.213(a)(2) for emission limitations into the RAS 1610.6-1613.8 MHz band from MSS space stations transmitting in the 1613.8-1626.5 MHz band. These space stations would be operating with a secondary service allocation and, pursuant to the Commission's proposed Rule 25.213(a)(2), must protect a primary service allocation. Motorola did not propose a similar relaxation in wording for proposed Rule 25.213(a)(3) for interference into another RAS band from MSS space stations operating with a primary service allocation. LQP supports the Commission's

[6] Cornell Comments, at 5.

proposed Rules 25.213(a)(2) and 25.213(a)(3) and urges the Commission to reject Motorola's suggestion.

2.2 Sharing with the Aeronautical Radio Navigation and the Radio Navigation-Satellite Services

2.2.1 Comments and Reply Comments from the FAA, ARINC, ATA, and Rockwell

In its Reply Comments, the Federal Aviation Administration (FAA) has stated that its current filing is not the forum for a detailed critique of LQP's analysis of sharing between MSS and aeronautical radio navigational satellite services. However, if the Commission determines that there are unresolved issues, then LQP suggests that the Commission utilize the Interagency Radio Advisory Committee (IRAC) or other appropriate fora, so that the Commission, the FAA, and the MSS applicants can discuss such issues.

In their respective comments, the FAA, Aeronautical Radio, Inc. (ARINC), Air Transport Association of American (ATA), and Rockwell International (Rockwell) all proposed that the Commission adopt a "transition plan" which would restrict MSS use of the band 1610-1616 MHz until the Russian GLONASS system had been shifted out of that band. LQP, in its comments, has demonstrated that a transition plan is not necessary or desirable. As an alternative, LQP proposed a plan which allows for the immediate utilization of GLONASS as part of the GNSS. All that is required of the GLONASS Administration is that it have available at least six GLONASS satellites operating on channel 6 or below with or without anti-podal operation for GNSS operability. This can be accomplished with the present generation of GLONASS satellites. None of the above commenters have presented any detailed system level analysis that shows a requirement for GLONASS satellites operating above 1606 MHz as a necessary component of GNSS. Moreover, the FAA has failed to discuss any need to utilize GLONASS in view of its plans to use alternatives to GLONASS to provide integrity measurements, including Wide Area Augmentation System (WAAS), barometric aiding, and local Differential GPS around airports.

Further, if the Commission decides to protect GLONASS in the 1610-1616 MHz band (where only GLONASS Channels 22, 23, and 24 are now operating) and the Commission sets the protection level due to out-of-band MES emission levels as requested by the FAA, then MSS operation for CDMA systems is virtually impossible in the 1616-1626.5 MHz band. MSS systems would not be able to operate in the 1616-1626.5 MHz band and meet the FAA protection levels for GLONASS in the 1610-1616 MHz portion of the band. Therefore, a transition plan is meaningless if the Commission adopts the protection levels for GLONASS as proposed by the aviation community.

The FAA incorrectly states in its comments that its analysis assumes an MSS-to aircraft separation of 100 feet as in the NRM Report, paragraph 3.3.4.2. The subject paragraph in the NRM Report states a separation distance of 100 m. Furthermore, the FAA continues to state 100 feet and then calculates path loss on the basis of 100 m and not 100 feet. The FAA's argument cannot be analyzed with so many contradictions in it.

With regard to the FAA's comment on the effect of encounters between aircraft and MES transmissions with extremely close separations being transient in nature, the Commission and the FAA can review the analysis on non-precision approach (NPA) operations previously provided by LQP.[7] The analysis demonstrates that MES emissions have no operational impact on NPA.

Based upon a simplistic analysis and with no detailed system analysis, the aviation community asks the Commission to impose a ban on MSS use of the band 1610-1616 MHz, 37.5% of the total band available for MSS service uplinks. Neither GPS nor GLONASS nor sponsors of the GNSS have demonstrated that corruption of a single GLONASS measurement will cause harmful degradation in the ability to navigate. Developing protection criteria on a single measurement basis, instead of the ability to navigate, is faulty system engineering.

With regard to the FAA's comments on a GPS protection bandwidth ten times greater than that requested at the NRM or as in proposed Rule 25.213 (b), a non-specific reference is made that "evolving techniques for the required accuracy for precision approach guidance require a wider GPS bandwidth." The response goes on to cite an unsubstantiated minimum required bandwidth of ±10 MHz (and, in the FAA's Reply Comments,[8] it states that up to ±15 may need to be protected) around the GPS center frequency of 1575.42 MHz. The only "evolving techniques" familiar to LQP, which could require protection ±10 MHz, are: (1) the so-called "codeless" techniques used for processing Precise Positioning Service (PPS) signals to obtain the ionospheric group delay time; and (2) the use of "narrow correlator" receivers which use the Standard Positioning Service (SPS) signal but require more bandwidth than the 2 MHz usually associated with this signal. A detailed response to the FAA's comments on a wider bandwidth are provided in paragraph

[7] See paragraph 4.2 of Attachment 1 of the Technical Appendix of Comments filed by LQP on May 5, 1994, Assessment of MES-Induced RFI on Hybrid GPS/GLONASS Aviation Receivers, April 29, 1994, Sat Tech Systems.

[8] Filed at the Commission on June 6, 1994.

2.2.2. But, in summary, codeless techniques are of questionable value and narrow correlator receiver response falls off rapidly with increasing bandwidth resulting in a questionable utility of this wider bandwidth protection.

Following are LQP's responses to additional issues raised by the FAA in its Reply Comments. On page 1, the FAA objects to evaluating the effect of MES out-of-band emissions on the ability of GNSS receivers to navigate as a benchmark for establishing out-of-band emission limits. The results of LQP's preliminary assessment described in Attachment 1 of the Technical Appendix to its Comments indicated that, for the assumptions made, there was no operational impact in en route airspace, terminal arc airspace, non-precision approach and for surface operations. This is an excellent starting point for the determination of protection criteria for ARNS. On page 2, the FAA refers to inconsistencies in the analysis presented in Attachment 1 to the Technical Appendix to LQP's Comments. LQP's responses follow:

- The analysis provided by LQP was based upon a nominal link budget and then modified on probabilistic grounds to account for potentially variable factors. The nominal value of EIRP density is 10 dB lower than the maximum value. The maximum value is accounted for in the probability function (shown in Exhibit 3-2) associated with the transmit power which is shown to increase by a value of 10 dB. Thus, the maximum value of EIRP density used in the analysis is -50 dB(W/MHz) as LQP proposed. This maximum value is of a short term nature and is represented as such by the probability function used.

- LQP calculated a positive link margin for the nominal conditions and also calculated a positive expected margin which takes into account the variability of system parameters. These link margins ranged from 6.1 dB to 16.9 dB. These link margins can be applied to all unknown factors including multiple MES emitters. Since the analysis is performed for a separation distance of 100 m between an MES emitter and an in-flight aircraft with a GNSS receiver, the range between the two will be at or near 100 m for a very short time and then the range will increase greatly, affecting the path loss between the emitter and receiver.

- The original analysis used a gain of 0 dBi for the GPS receive antenna gain. This gain has been revised downward in the analysis in Attachment 1.

- Required C/I values of -24 dB and -22 dB were used for the GPS and GLONASS analyses, respectively. These are the values found in ARINC Characteristic 743A-1 as well as the values used by the FAA in Table 1 of its Comments. The FAA's reference in their Reply Comments to 21 dB does not provide a reference or a reason for the change.

The nominal GPS link margin was over 6 dB with an expected improvement in margin due to variable factors of over 10 dB. This provided a very low probability that the expected C/I would be below -24 dB. The LQP analysis has been revised to include issues raised by the FAA and is presented in detail in Attachment 1 of the Reply Comments Technical Appendix.[9] (This updated analysis is summarized in paragraph 2.2.3.) These issues include variability in GPS and or GLONASS antenna gains in the direction of the desired signal, receiver line losses of 1.5 dB, and anticipated GLONASS received signal levels.

With regard to page 4 of the FAA's Reply Comments, the LQP analysis evaluates the ability to navigate using GNSS operating in an environment where MSS systems are operating in the adjacent band. This will occasionally produce low levels of MES interference within the GPS and GLONASS operating bands. (For GLONASS channels 22, 23, and 24, the interference level will be higher as these GLONASS channels would be operating co-frequency; however, as the analysis shows, these higher GLONASS channels are not required for GNSS.) Exhibits 3-5 and 3-6 in Attachment 1 hereto provide the expected link margin and probability of exceeding J/S specifications for GLONASS channels -6 though 12 and also channels 22, 23, and 24. More than one GLONASS frequency was analyzed as to the effect of interference and the ability to navigate. (A reference to "surgical interference mechanism" is unclear.) The analysis has shown that there is a probability of about 6.5 times 10^{-4} that the J/S ratio will be exceeded in a GLONASS channel (after the GLONASS frequency plan revision). The effects of this probability combined with GPS operations are then evaluated for the various phases of flight. Any system design and analysis including a safety of life aeronautical navigation system should be concerned with interference from systems sharing the same band as well as those systems operating in adjacent bands. The system design should include link budget analyses as well as an

[9] See Attachment 1 of this Technical Appendix, Assessment of MES-Induced RFI on Hybrid GPS/GLONASS Aviation Receivers, Revised June 1994, Sat Tech Systems.

assessment of the ability to maintain the safety of life navigation capability. Indeed, LQP has presented such an analysis in Attachment 1 to this Technical Appendix. This revised analysis shows that there is no operational impact from MES in these various phases of flight on the ability to navigate when utilizing GNSS.

2.2.2 FAA's Request for Wider Protection Bandwidth for GPS

This section replies in detail to the FAA's request for a wider protection bandwidth for GPS, specifically those "evolving technologies" which could require protection ±10 MHz (or up to ±15 MHz as mentioned in the FAA's Reply Comments). They are: (1) the so-called "codeless" techniques used for processing Precise Positioning Service (PPS) signals to obtain the ionospheric group delay time; and (2) the use of "narrow correlator" receivers which use the Standard Positioning Service (SPS) signal.

2.2.2.1 Codeless Techniques

These techniques involve the use of the GPS PPS signals, which will normally be encrypted by the DoD. Some researchers believe that codeless techniques have the potential to provide aircraft-autonomous ionospheric corrections through cross-correlation of the unknown PPS signal on the L1 and L2 channels. However, the stated U.S. policy is that the PPS is not intended for civil use. Its use in the civil domain is neither authorized nor sanctioned by the U.S. Government, and is specifically excluded from the specifications and standards that define the GPS SPS provided to the civil community. Thus, there is no legal or regulatory basis for protecting these functions in civil aviation navigation.

The primary benefit of codeless processing is the potential to determine the differential ionospheric delay between the PPS signal transmitted on L1 and PPS signal transmitted on L2. This differential delay can be used to estimate the ionospheric propagation delay for each signal alone, allowing correction to the standard pseudorange measurements made by the receiver. However, since the

PRN sequence of the PPS signal is encrypted with a secure key, the PPS signal must be correlated in its full two-sided bandwidth of approximately 20 MHz. Several variants of the cross-correlation technique are currently being investigated by the survey and precision navigation community, but they all rely on nonlinear processing and hence are inherently less reliable than standard correlation and tracking techniques usually applied to the GPS SPS.

There are serious doubts regarding the efficacy and utility of codeless techniques applied to precision approach and landing. Codeless techniques were pioneered by the land surveying community, whose members can normally setup and dwell at a fixed site for a reasonably long period of time. Codeless receivers typically implement nonlinear processing and exceedingly narrow tracking loops in order to cross-correlate the encrypted signals and compensate for sharply elevated noise floors associated with codeless processing. These narrow tracking loops are not operationally feasible with an aircraft maneuvering dynamically on final approach—especially in foul weather conditions. Discussions in TRCA/SC-159 have addressed this point; for example, Dr. A.J. Van Dierendonck, an internationally recognized expert in GPS receiver technology, has presented several working papers in this forum which indicate that codeless receivers cannot reliably maintain lock on an airborne platform during even moderate dynamics. This appears to be a fundamental problem, not easily surmounted by new or innovative receiver technologies. Furthermore, in addition to its serious technical risk, the codeless technique is *not required* in order to achieve a precision approach capability. The FAA's Wide Area Augmentation System (WAAS) will provide ionospheric corrections to airborne users in all flight regimes, which should eliminate the need for autonomous determination of ionospheric delay.

The WAAS ground monitoring stations may use codeless techniques (although they may be authorized to access (decrypt) the PPS directly). These sites will be proliferated and only loosely connected to the real-time performance of airborne users (i.e., the raw data from many monitor sites will be fused to generate the ionospheric corrections, which will typically change slowly over time). Furthermore, the siting and RF environment of the monitor stations is easier to control than that of an airborne user. The FAA plans to incorporate aggressive techniques for interference mitigation in these highly capable and sophisticated installations.

All codeless techniques hinge on the processing of the normally encrypted PPS signal which is unreliable from a moving platform. Alternative techniques, such as standard differential GPS (DGPS) and kinematic or carrier-phase DGPS, achieve higher levels of accuracy with greater reliability and less risk. Therefore, no compelling reason has been provided to justify protection of the GPS PPS spectrum in a way that would support unauthorized civil access. It should be noted the MES emissions would be completely insignificant to an *authorized* PPS user, who would be able to despread the signal via standard techniques.

2.2.2.2 Narrow Correlator Receivers

Another recently developed technique, which requires bandwidth greater than the nominal SPS or C/A code main lobe, is the narrow correlator approach to improving the accuracy and stability of the C/A code tracking process. However, this technology has been shown to reach a point of diminishing returns well before bandwidths of ±10 MHz. Because of the spectral fall-off of the PN process, there is essentially no performance benefit beyond bandwidths of about ±5 MHz. Furthermore, the standard correlation process de-emphasizes noise contributions outside the main lobe. LQP has accounted for this factor in its analysis, conservatively integrating the noise floor over ±10 MHz with a $(\sin(x)/x)^2$ weighting function. As a result, LQP's analysis is already consistent with the use of this technology.

2.2.2.3 Summary on Wideband GPS Protection

There are serious technical and regulatory concerns regarding experimental techniques that would require bandwidth protection ±10 MHz around the GPS L1 frequency of 1575.42 MHz. LQP urges the Commission to reject these concepts as a basis for frequency management. With regard to the narrow correlator technology, which requires expanded bandwidth on the order of ±5 MHz, LQP's analysis has already incorporated the effects and clearly shows the lack of operational impact.

2.2.3 Revised Assessment of GLOBALSTAR Emissions on GNSS Navigation Performance

The assessment of GLOBALSTAR MES emissions on GNSS receiver navigation performance submitted by LQP as Attachment 1 to the Technical

Appendix in its Comments has been revised and addresses some of the comments made by the FAA and others.[10] This assessment focused on the operational impact of MES emissions on user navigation performance relative to generally accepted standards of Required Navigation Performance (RNP) as a function of user phase of flight. Analytic refinement is possible and desirable in many areas:

1. The definition of RNP is evolving. Internationally, the ICAO RGCSP (Review of the General Concept of Separation Panel) and AWOP (All Weather Operations Panel) are attempting to forge a broad consensus on the definition of RNP. Domestically, the FAA is initiating an effort to redefine the basic requirements documents for the National Airspace System in terms of RNP. The precise definition of RNP and threshold levels for each phase of flight are being refined through analysis and consensus.

2. MES operating characteristics are projections. The characteristics assumed herein are subject to refinement.

3. GNSS receiver operating characteristics and performance requirements should be improved. The prior requirements were driven by formal specifications, which have ignored advancements in technology and normal engineering margins. In particular, the analysis reported here assumes that navigation performance could be lost at J/S ratios that marginally exceeded the ARINC Characteristic 743A- 1 specifications. Therefore, upgraded specifications which would improve MSS sharing are required as discussed by ARINC at the NRM.

4. GNSS constellation expected performance levels are projections. As operational confidence in GNSS builds over time, and as historical experience dictates, assumed failure rates would be adjusted. Further analysis is also required to extend currently-available performance data, which were derived from assumptions that do not precisely match projected GNSS operations scenarios or evolving certification requirements.

[10] See Attachment 1 to the Technical Appendix of the Comments filed by LQP on May 5, 1994, Assessment of MES-Induced RFI on Hybrid GPS/GLONASS Aviation Receivers, April 29, 1994, Sat Tech Systems.

5. Future GNSS receivers may incorporate enhanced signal rejection technologies. The specifications for GNSS receivers that will operate in conjunction with WAAS, and provide true sole means navigation capability via GNSS, are currently being developed. Interference assessment analyses are ongoing in the aviation community, and RFI mitigation techniques are being evaluated with an eye toward enhancing GNSS receiver robustness. These mitigation techniques include filtering, revisions in the A/D conversion circuitry, and other changes.

In spite of these influences, a revised worst case MES impact assessment has been completed. The U.S. requirement for barometric aiding (via TSO C129) significantly improves the expected level of performance of the most disadvantaged user in U.S. airspace. From a visibility standpoint, a full GPS constellation with two additional geosynchronous spacecraft is sufficient to satisfy all accuracy, availability and integrity requirements in all phases of flight except precision approach. If differential corrections are available through the geosynchronous spacecraft, Category I precision approach requirements can be satisfied as well. Similar performance can be achieved with a full GPS constellation and six additional satellites operated in coordination with GPS. The expected incidence of satellite failures and short-term outages (e.g., due to maneuvers) will increase the requirements. However, reliability studies indicate that only a small increase in the number of visible satellites will be required. These studies need to be refined and extended with a specific focus on GLONASS, lower mask angles (5 degrees) and barometric aiding. Nevertheless, data available to date indicate that acceptable performance can be maintained with GPS plus one-fourth to one-half of the GLONASS constellation.

In U.S. airspace, it is important to recognize that certificated GNSS receivers will incorporate barometric aiding, and will have additional ranging signals (and integrity information) from typically two additional geosynchronous spacecraft in the timeframe of MSS operations. The impact of ground-derived integrity data on system performance was not included in the analysis reported here, but also would be expected to significantly improve performance and reduce constellation requirements.

From an availability standpoint, there is no assessed requirement to track GLONASS satellites operating on channel assignments above 1606 MHz. The current GLONASS frequency plan provides six spacecraft operating channels containing the C/A code below 1606 MHz. With anti-podal assignments, GLONASS would offer an availability for integrity benefit equivalent to approximately four geosynchronous spacecraft. However, as few as two geosynchronous spacecraft were shown (in Section 4 of Attachment 1) to satisfy sole means availability requirements in all phases of flight, as well as accuracy, availability, integrity, and continuity requirements for en route, terminal area and NPA operations. (Note: Category I precision approach and surface operations require a differential overlay to enhance accuracy, and Category I precision approach also benefits from a differential overlay to enhance integrity. A WAAS would also provide additional ranging signals to enhance availability further.)

The conclusion of the MES impact assessment is that there is no operational impact to en route airspace, terminal area airspace, non-precision approach and for surface operations using the LQP proposed MES out-of-band emission limits to protect GPS and GLONASS, as suggested in paragraph 2.2.5. For Category I precision approach, continuity of service may be affected under a conservative set of analytic ground rules in cases where a GNSS user relies on GLONASS during the approach to provide needed additional integrity assurance for safe operations. This is not a likely mode of operations in the United States, although it may exist elsewhere. Furthermore, within the United States and adjacent regions, planned augmentation such as the WAAS will be sufficient to support primary means navigation down to Category I minima without reliance on GLONASS.

For users who choose to depend on GLONASS in lieu of, or in addition to the WAAS, a potential interference mode exists. For these users, the presence of an active MES close to the extended runway centerline in a narrow region approximately 0.75 miles from runway threshold, operating in a shadowed mode (resulting in a higher power MES transmission), could lead to loss of GLONASS signal tracking, and, therefore, potential loss of navigation system integrity even though navigation guidance is not lost at this point, or even necessarily degraded. In this situation, the user's avionics could potentially declare an integrity alarm that could lead to a missed approach.

Whether an integrity alarm is actually declared depends on numerous real-time parameters as well as the possible existence of alternative navaids, such as, inertial reference systems or others. It is emphasized that almost any change in the underlying assumptions for this scenario would eliminate the possibility of signal tracking degradation. These changes include: (1) reliance on the WAAS; (2) reliance on WAAS ranging signals and on a local DGPS correction and integrity broadcast; (3) less than full power MES operations; (4) GNSS antenna directive gain less than -5 dBi toward the MES; (5) airframe or environmental shielding; (6) GNSS signals above minimum specified received power levels; or (7) GNSS receiver performance that exceeds the conservative ARINC 743 A-1 J/S specifications.

This assessment supports LQP's position that:

1) GLONASS satellites operating on channels 1 through 6 in an antipodal manner are sufficient to provide GNSS with the desired integrity. Specifically, GLONASS channels 22, 23, and 24 plus channels 7 through 12 are not required nor should they become part of GNSS;

2) Completion of the GLONASS constellation on channels -6 through -1 will continue to improve satellite visibility statistics; and,

3) The LQP proposed MES e.i.r.p. density limits are appropriate since it has been shown that the MES units will not interfere with aviation users' ability to navigate using GNSS. There is no operational impact in en route airspace, terminal area airspace, non-precision approach and for surface operations using the LQP proposed MES out-of-band emission limits to protect GPS and GLONASS as proposed.

2.2.4 Filtering of GNSS Receivers

With the planned revision to the GLONASS frequency plan, the aviation community should take the appropriate action to ensure that the GNSS receivers are properly designed with respect to filtering at the input to the receiver. The second generation GLONASS channelization includes a top center frequency of 1615.5 MHz with primary C/A code components extending out to 1616 MHz. Therefore, if protection of GLONASS channels 22, 23, and 24 is required by an interim or transition plan, receivers would be designed to encompass signals as high as 1616 MHz. Then, when GLONASS accomplishes its frequency plan revision with its third and fourth generation satellites, the highest carrier frequency will be at 1605.375 MHz and the highest primary C/A code component will occur just below 1606 MHz. Therefore, receivers built with filtering at 1616 MHz will no longer be adequate, since there will be many MES units operating worldwide in the MSS band just above 1610 MHz as shown in Figure 2.2-1. The effects of several of these MES units operating within the 1610-1616 MHz range could cause impaired operation of the receiver. Now is the time to ensure that GNSS receivers are properly designed for the revised GLONASS frequency plan. The Commission can ensure that receivers are built to specifications which will protect the navigation function when GLONASS is operational below 1606 MHz by not requiring protection of GLONASS channels 22, 23, and 24, or any other GLONASS channel(s) which lie in the primary MSS uplink band between 1610 and 1626.5 MHz.

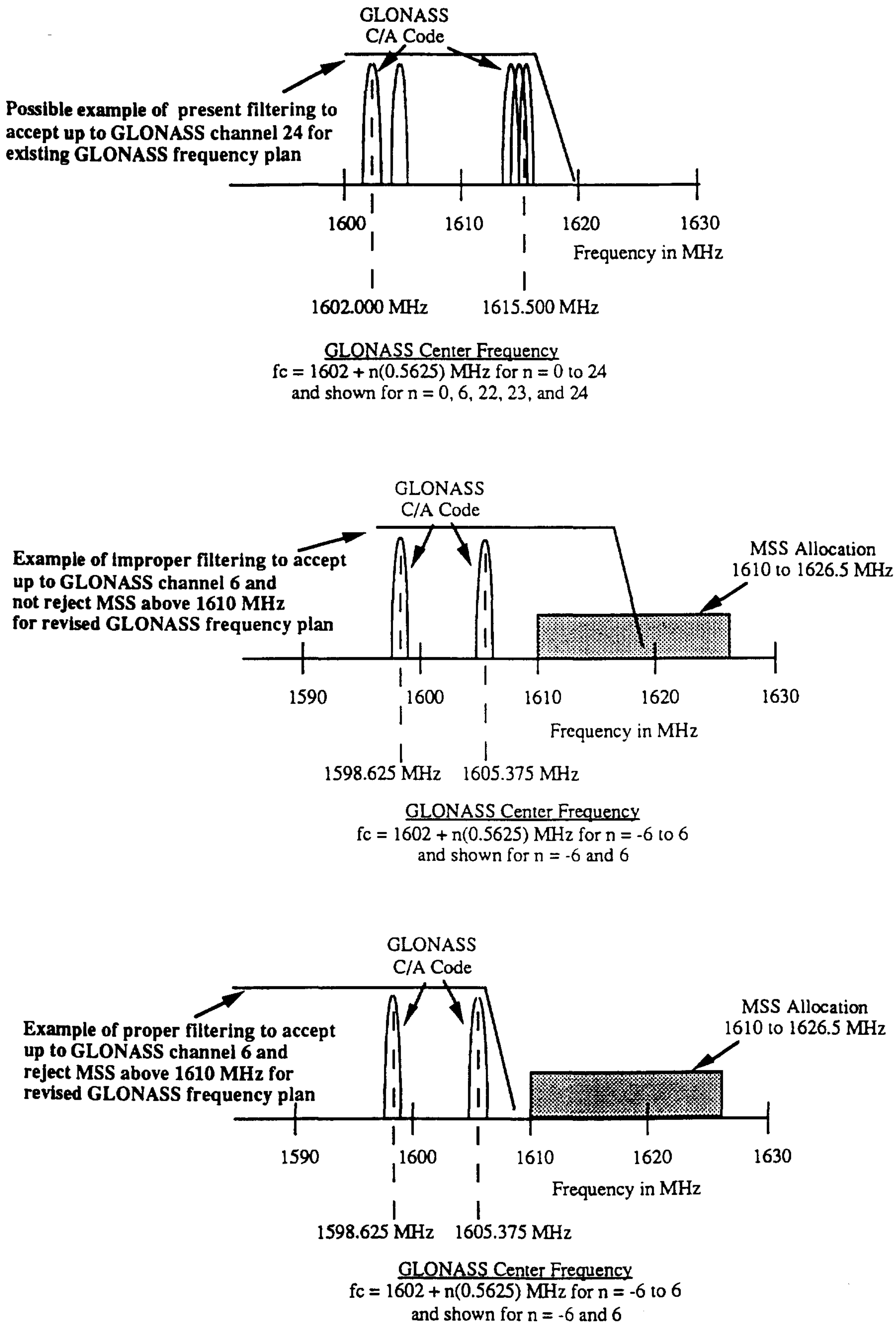

Figure 2.2-1 GNSS Receiver Input Filter Considerations

2.2.5 Suggested Modifications to the Commission's Proposed Rules Concerning ARNS/RNSS

LQP is well aware of the need to protect ARNS in the bands of interest below 1610 MHz. Based upon the results of the LQP sponsored analysis summarized above and presented in detail in Attachment 1, LQP proposes the following modifications to the Commission's proposed rules to protect both GPS and GLONASS as part of GNSS. A lower value of MES e.i.r.p. density is being proposed to protect GPS based upon this revised analysis. The lower e.i.r.p. density value represents a significantly lower probability of exceeding the GPS J/S ratio of 24 dB from 6.5×10^{-4} to 2.5×10^{-6}. This should greatly help to alleviate the FAA's concerns over unknown factors

Therefore, LQP proposes the following composite change to the first sentence in proposed Section 25.213 (b) to encompass both GPS and GLONASS as part of GNSS. Protection in the portion of the 1559-1610 MHz band used by GLONASS should be eliminated if GLONASS does not become an integral component of GNSS:

> *Protection of the radio navigation-satellite service operating in the 1559-1610 MHz band. Mobile Earth stations operating in the 1610-1626.5 MHz band shall limit out-of-band emissions in the 1574.397-1576.443 MHz band and the 1598 to 1606 MHz band so as not to exceed an e.i.r.p. density level of -55 dB(W/MHz) and -50 dB(W/MHz), respectively, averaged over any 20 ms period.*

With this protection afforded to the GLONASS component of GNSS, LQP proposes that the last two sentences of proposed Rule 25.213 (c) (1) be deleted and that the first and, now, only sentence be modified to read:

> *(1) Mobile-satellite Earth stations transmitting in the 1610-1626.5 MHz band shall limit e.i.r.p. density levels to no greater than -15 dB(W/4 kHz) on frequencies being used by systems operating in accordance with International Radio Regulation RR 732, and to no greater than -3 dB(W/4 kHz) on frequencies that are not so being used.*

In Appendix A, Proposed Rule Text Modifications (pp. 5 and 6), of its Comments, Constellation Communications, Inc., also suggested the same modification to the proposed Rule 25.213 (c) (1).

2.2.6 Summary of Sharing with the Aeronautical Radio Navigation and the Radio Navigation-Satellite Services

The following offers both a summary of the LQP proposals on sharing with Aeronautical Radio Navigation Service as well as recommended strategy negotiations with the Russian GLONASS Administration. LQP proposes that the Commission encourage the U.S. Government take appropriate action to ensure the following:

- Afford protection for both GPS and GLONASS as part of GNSS in the 1574.397-1576.443 MHz and 1598-1606 MHz bands as recommended in LQP's revision of the Commission's proposed Rule 25.213 (b) above.

- Protect GLONASS above 1610 MHz only as proposed in LQP's revision of the Commission's proposed Rule 25.213(c) above.

- Seek to modify Radio Regulation 731E at future ITU World Radiocommunication Conferences in accordance with LQP's revision of the Commission's proposed Section 25.213 (c) above.

- Encourage the Russian GLONASS Federation to populate the GLONASS constellation with satellites operating in an anti-podal manner on channels 1 through 6, such that they will be protected as part of GNSS.

- Encourage the Russian GLONASS Federation to implement its planned frequency revision as quickly as possible to reduce interference into the Radio Astronomy Service.

- Advise the Russian GLONASS Federation that the US Government intends to promote MSS operations on a worldwide basis in the 1610-1626.5 MHz band and will grant licenses to US MSS operators in the near future to operate over this entire band.

- Advise the aviation community and proponents of a GPS and GLONASS based GNSS system that receiver design specifications should account for the revised GLONASS frequency plan of operations on channels -6 through +6 only and of the necessity to incorporate proper input filtering for an upper frequency of 1606 MHz and not the present 1616 MHz.

- Afford no protection of GLONASS channels operating in channels 22, 23, and 24.

- Advise the aviation community that GNSS receiver designs should be designed with filters that reject signals above 1606 MHz.

2.3 Terrestrial Services

2.3.1 Sharing with the Fixed Service in the 2483.5 - 2500 MHz Band.

As mentioned in TRW's Comments on sharing with the Fixed Service (FS), the ITU Radiocommunication Bureau (ITU-R) has established Task Group 2/2 to address sharing issues relating to the FS and the MSS. An LQP-sponsored study has been completed to determine the conditions for sharing between the GLOBALSTAR non-GSO mobile-satellite system and FS systems operating in the 2483.5-2500 MHz band. The methodology and parameters used for the study are based on the latest guidance from ITU-R Task Group 2/2: Recommendation ITU-R (Doc. 9/178) for the methodology;[11] and, Doc. 2-2/TEMP/8 (Rev.1) for the technical parameters for both analog and digital point-to-point and point-to-multipoint FS systems.[12] This study has shown that a power flux-density (pfd) of -147 dB(W/m^2) in a 4 kHz bandwidth for elevation angles less than 5 degrees, linearly increasing to -134 dB(W/m^2) in a 4 kHz bandwidth for elevation angles greater than 25 degrees will provide protection consistent with Recommendation ITU-R F.357-3[13] to 2500 km hypothetical reference circuit employing analog point-to-point radio-

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[11] "Determination of the Criteria to Protect Fixed Service Receivers from the Emissions of Space Stations Operating in Non-Geostationary Orbits in Shared Frequency Bands," Draft New Recommendation, Document 9/178-E, 13 October 1993.

[12] "Technical Characteristics of Fixed Service Systems in the 1-3 GHz Band," Document 2-2/TEMP/8(Rev.1)-E, 7 February 1994.

[13] "Maximum Allowable Values of Interference in a Telephone Channel of an Analog Angle-Modulated Radio Relay System Sharing the Same Frequency Bands in the Fixed-Satellite Service," Recommendation ITU-R F.357-3, Recommendations of the CCIR, Vols. IV and IX, Part 2, XVII Plenary Assembly, Dusseldorf, 1990, pp. 5-6.

relay techniques. Sharing with point-to-point and point-to-multipoint radio-relay systems employing digital techniques was found to require pfd levels that are about 7 dB less than the values currently specified in RR 2566 to meet the protection requirements of Recommendation ITU-R (Doc. 9/178).

The results of this study provided the basis for a recent LQP contribution of a preliminary draft new recommendation (PDNR) to USTG 2/2[14] and is included here in Attachment 2. The main points made in the PDNR are:

- Non-GSO mobile-satellite systems may need to operate at pfd levels in excess of those specified in RR 2566 in order to meet basic service quality objectives for portable hand-held devices;

- Higher pfd levels are consistent with the protection requirements of Recommendation ITU-R F.357-3 when applied to analog radio-relay systems;

- Protection of analog radio-relay systems should be used as the basis for developing appropriate threshold values of pfd; and,

- The following values of pfd per satellite should be used as coordination threshold values between non-GSO/MSS downlinks and the fixed service:

-147 dB(W/m^2/4 kHz)	for 0 < Ø < 5 degrees,
-147 + 0.65 (Ø-5) dB(W/m^2/4 kHz)	for 5 < Ø < 25 degrees, and
-134 dB(W/m^2/4 kHz)	for 25 < Ø < 90 degrees,

where Ø is the angle of arrival from the satellite at any point on the surface of the Earth.

These pfds are 2 dB higher than that proposed in LQP's Comments. LQP's most recent analysis concludes that these values can be used without causing harmful interference into analog point-to-point or point-to-multipoint radio relay systems.

[14] "Preliminary Draft New Recommendation, Criteria for Sharing between the Mobile-Satellite (Space-to-Earth) Non-GSO Systems and the Fixed Service in the 2483.5-2500 MHz Frequency Band," Document USTG 2-2/2(Rev.1), June 13, 1994.

2.3.2 Fixed Services above 2500 MHz

In its comments, the Wireless Cable Association International, Inc. (WCAI), states that MSS proponents need to consider low-cost broadband repeaters used in ITFS systems as an additional source of interference to Mobile Earth Stations (MES). WCAI accurately describes these devices as being generally wideband amplifiers used to relay signals into areas that are otherwise unserviceable due to terrain blockage or man-made obstructions. WCAI further notes that the Commission has authorized these low-cost devices as an effective vehicle by which ITFS licensees and wireless cable system operators can service "additional areas." WCAI states that the MSS industry has failed to indicate how it would eliminate out-of-band emissions from these important devices without increasing their cost to impractical levels.

Based upon interference estimates provided in its comments, LQP believes that operation of these broadband repeaters to cover these "additional areas" will not appreciably increase the out-of-band interference it expects from the ITFS. LQP's estimates were based on an analysis of FCC license records, FCC rules, ITFS equipment characteristics, and a series of measurements made in the San Francisco Bay area. LQP's conclusion was that it could "work around" the localized interference that might be caused by the only ITFS channel that could possibly cause any interference to MSS, Channel A-1, which operates just above at the edge of the band between ITFS and MSS at 2500 MHz.

Taking these broadband repeaters into account, LQP maintains the position expressed in its comments: LQP will be able to operate successfully with interference from ITFS and does not seek any change in the out-of-band emission limits for ITFS stations.

FCC rule Section 21.913, "Signal booster stations," which was adopted as part of the Wireless Cable Order,[15] placed several restrictions on the operation of such booster stations. They "may not extend service beyond the boundaries of an MDS station's protected area" [§21.913(a)], the "power flux density at the edge of the MDS protected service area [may] not exceed - 75.6 dBW/m^2" [§21.913(c)], "no harmful interference may be caused to co-channel and adjacent-channel existing or previously-proposed ITFS and MDS stations with transmitters within 50 miles of the proposed booster station's transmitter site" [§21.913(d)], and "the output power of the signal booster station must not exceed 18 dBW EIRP" [§21.93(f)]. The prohibition against booster stations causing co-channel or adjacent-channel interference to ITFS and MDS stations and the requirement for an 18 dBW limitation on e.i.r.p. cited above, are embodied in the rule applying to ITFS stations [§74.985].

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[15] "Amendment of Parts 21, 43, 74, 78 and 94 of the Commission's Rules Governing Use of the Frequencies in the 2.1 and 2.5 GHz Bands," 6 FCC Rcd 6792, 6797 (1991) [Report and Order in General Dockets Nos. 90-54 and 80-113, Adopted October 11, 1990].

However, these rules, taken together, and considering the manner in which signal booster stations are being used, indicate that signals from the ITFS stations on Channel A-1 will not increase the stations' effective service radius (or area) and will therefore not cause appreciably more interference to MES receivers than considered in LQP's Comments.

Typically, broadband repeaters are employed by an MDS service provider to fill in coverage gaps in all of the channels on which programming is being transmitted to its customers. Those channels include ITFS, MDS, MMDS and OFS channels leased from their respective licensees. Thus, the location, power, and antenna gain and directivity of a broadband repeater carrying one or more ITFS channels and at least one MDS, MMDS or OFS channel, would be bound by the more restrictive rules of Part 21 of the Commission's Rules, in particular, the rule prohibiting a signal booster from increasing the service area.

In practice, the majority of these broadband signal boosters have very low power -- on the order of -4 dBW -- that is, about 400 milliwatts -- and are used to fill in small areas where coverage is blocked by an intervening man-made or natural object such as a building or a hill. Therefore, broadband signal boosters will be no more likely to produce interference through overload of the MES receiver than would the primary ITFS transmitters.

WCAI is concerned that MES will experience interference from ITFS Channel B-1, which operates between 2506-2512 MHz. LQP believes that the existing out-of-band emission limitations [§74.936(b)], plus the frequency separation of Channel B-1 from the MSS band, are adequate to prevent it from contributing to MES interference either directly or through intermodulation with Channel A-1.

In response to the question posed by the Commission, WCAI states that "one manner in which MSS operators could avoid harmful interference from [ITFS] operations in the 2.5 GHz band is to avoid operating in those areas where ITFS transmitters and wireless boosters are utilized." LQP proposes to operate in essentially that manner: LQP will avoid harmful interference from ITFS operations above 2500 MHz by assigning frequencies to an MES in the vicinity of ITFS Channel A-1 (and any booster station carrying its signal) which are sufficiently below the band edge at 2500 MHz to prevent interference to that MES.

Regarding the question of future interference from ITFS stations employing digital modulation, LQP agrees with WCAI that it is premature to estimate when a conversion to digital will begin and how rapidly it might occur. Furthermore, in view of the uncertainty over which digital modulation scheme or schemes may eventually be employed by ITFS, it cannot be stated with any degree of confidence whether the interference situation will be of any more consequence that it is now.

For all these reasons, LQP urges the Commission to allow MSS operators access to all the frequencies in the band 2483.5-2500 MHz without any change in the out-of-band limitations on ITFS stations in the band above 2500 MHz.

2.3.3 ISM Emissions at 2400-2500 MHz

In its comments, TRW's preliminary evaluation (p. 133 n. 209) of its tests of microwave ovens indicated that "they will not produce serious interference," and that "the BER was not degraded in most situations when a test link was transported through the city streets and the extensive freeway system of Los Angeles." Nevertheless, TRW commented that "it would seem appropriate for the Commission to reassess the permissible levels of unwanted emissions from ISM devices."

LQP does not seek any such reassessment nor does it deem it necessary prior to the establishment of the rules governing the MSS. Delaying the MSS licensing process to accomplish a reassessment is not necessary or desirable. Even if such an assessment should result in a Commission decision to require lower radiated and conducted emission levels from microwave ovens, LQP does not believe that it would have any effect on reducing the interference in the environment in which MSS will have to operate. The millions of ovens now operating throughout the United States and the rest of the world, plus the millions more that will be placed in operation before any significant quantity of ovens with lowered emission levels might be offered for sale, represent the environment in which MSS will be operating. LQP believes that it can operate satisfactorily in that environment using the operational techniques it outlined in its comments.

Since the submission of its initial comments, LQP has continued to perform testing of the effects of ISM emissions on the performance of wideband CDMA receivers. As described in the LQP Comments, recorded sequences of ISM interference were made by driving a van equipped with recording test equipment throughout the San Francisco Bay metropolitan area. While this area does not represent the suburban and rural environment in which GLOBALSTAR primarily intends to operate, the intent of the urban measurement campaign was to capture "worst-case" data to identify the highest levels of ISM interference which might be encountered in highly-populated industrial circumstances. As might be expected, the test interval with the very worst interference was recorded mid-afternoon while on an elevated freeway in the city of San Francisco between an industrial area and downtown skyscrapers.

From this extreme ISM environment, the recorded sequences were scored by the severity of ISM interference, and the worst 13% of the sequences from the urban industrial area were selected. In the laboratory, these "worst-worst" case recorded sequences were repetitively and continuously injected into a wideband CDMA receiver to stress its performance. As additional stress, the signal-to -noise ratio of the receiver was reduced to 1 dB below its nominal level. The CDMA receiver was alternatively receiving voice or data traffic. In the situation where data was being communicated, only 4% of the recorded sequences of the defined worst-case, urban-environment ISM interference produced an unacceptably-high frame error rate; in addition, no calls were dropped, even after the injected interference was artificially increased another 8 dB. When voice was being communicated, the same worst-worst 4% of the segments caused some impairment. Exposed to the remaining 96% of the recorded ISM sequences, voice performance could not be distinguished from the clear non-interference signal condition.

Additional measurement campaigns have been run which have collected ISM interference data from suburban, rural, and less-dense urban environments in the Central Valley of California northeast and east of San Francisco. There, the severity of ISM interference was found to be – as expected – less than that encountered in the San Francisco Bay region. In fact, in the rural and suburban environments, measured values corresponding to those from the heavy industrial San Francisco were never found. Rural and suburban interference peaks were measured to be 15 to 20 dB less than those measured in the urban environment, and the duty factor of CDMA receiver threshold exceedance in rural and suburban environments was insignificant (less than 5%) when compared to urban environments (exceeding 30% in the worst-worst 4% segments). In comparison to the severe stress testing described above, the impact on CDMA receiver performance of the lower-magnitude ISM interference found in rural and suburban conditions will be negligible.

SECTION 3

3.0 Feeder Uplink Sharing Analysis at 5 GHz

In its comments, FAA expressed concern over the potential use of the 5150-5250 MHz band for use by MSS systems for feeder links. It emphasized this concern in its Reply Comments, for the entire 5000-5250 MHz band ARNS allocation. In the past, the feeder link discussion has focused on use of this band for MSS feeder downlinks, primarily in the 5150-5216 MHz segment of the band and also the 5150-5250 MHz band. LQP, in response to FAA concerns, is providing two separate analyses of the feasibility of GLOBALSTAR feeder uplinks sharing the band with the FAA's planned microwave landing system (MLS). During the period that this analysis has been ongoing, the FAA has announced that development of the MLS systems has been canceled, and, therefore, current use of this 5000-5250 MHz band is negligible.

A summary of results of the 5 GHz MSS/MLS sharing analysis by Comsearch of Reston, VA, and Sat Tech Systems of Arlington, VA, follow. Complete analyses are provided in Attachments 3 and 4, respectively. The following information is presented to show that currently deployed MLS sites can be effectively coordinated and that the techniques employed are applicable to other services that the FAA may deploy in these bands. It should be noted that LQP believes there are no operational aircraft equipped with MLS equipment.

The proposed GLOBALSTAR feeder uplink frequency band segment of 200 MHz for MSS gateway operations within the 5000-5250 MHz band overlaps the existing frequency allocation for the Microwave Landing System (MLS). As a result, it is necessary to evaluate the potential for coexistence and frequency coordination within the band. Comsearch has undertaken a preliminary assessment of the possibilities of sharing the 5000-5250 MHz frequency band between the GLOBALSTAR feederlink and the FAA's proposed microwave landing system (MLS). Fundamental research into the operations of MLS was conducted, and interference case study analyses were performed. The case study indicated that terrain, artificial shielding, or other interference reduction measures can be undertaken in order to achieve sharing. In addition, frequency coordination can be used but would be minimized or eliminated should the selected feederlink site be located in non-congested area. With MLS systems having a limited deployment, it is unlikely that this would be necessary.

Overall, sharing is feasible with the studied parameters, the appropriate selection of the feederlink gateway site, and the application of certain interference reduction techniques, such as artificial shielding and utilization of terrain blocking. In addition, frequency planning, as well as, sound procedures in spectrum management, could be introduced for optimal spectrum utilization.

The report on the analysis by Sat Tech Systems describes and evaluates the levels of radio frequency interference (RFI) generated by MSS gateway operations in the 5000-5250 MHz band in relation to MLS specifications, and demonstrates that coexistence and frequency coordination is feasible and easily achieved. Complete protection of MLS operations can be assured through standard and straightforward frequency management techniques.

Noting that GLOBALSTAR will operate few gateway stations in the United States, it is recommended that coordination be performed on a site-by-site basis. Techniques that can be used to assure complete protection of MLS operations include:

a) physical separation between MSS gateways and MLS ground sites;

b) terrain masking;

c) RF fences engineered and constructed near the MSS gateway, to specifically enhance signal blockage in the direction of MLS service volumes;

d) antenna stops in the MSS gateway antenna that preclude antenna boresight aiming in selected azimuth/elevation sectors associated with MLS service volumes inside the radio horizon; and

e) software control of MSS frequency assignments such that specific frequencies surrounding MLS channel assignments in the neighborhood of the MSS gateway are avoided when the gateway antenna boresight is within predefined azimuth/elevation sectors.

Section 7 of Attachment 4 illustrates one candidate coordination scenario which combines physical separation, an RF fence and physical antenna stops in the mechanical assembly of the MSS gateway antenna. These physical mitigation techniques are shown to guarantee full protection to MLS operations. A wide variety of alternatives may be configured, dependent on the characteristics of specific MSS gateway locations and their geometries relative to MLS ground sites located within a range of roughly 200 nmi.

The recent MLS program decisions by the FAA, effectively canceling the MLS program except for those systems already built and in the inventory, imply that the number of MLS ground sites will be extremely limited within the United States. Current planning indicates 19 ground sites within the lower 48 states and 11 in Alaska. In Europe and elsewhere, the reported use of MLS is declining, and shifts to satellite based systems are occurring. This would parallel the evolution within the United States. Therefore, worldwide coordination of MSS gateway operations should be straightforward and easily achieved.

It is noted that as an output of its recently concluded meeting of the International Telecommunication Union Study Groups (ITU-R) on June 10, 1994, Task Group 4/5 (concerned with feeder links for MSS systems) took the preliminary view in a liaison statement to other ITU-R groups that sharing of non-GSO MSS feeder-links (both downlinks and uplinks) with aeronautical radio navigation service systems in the 5.00-5.25 GHz band appears feasible, since the interference into MLS receivers would be within the assumed permissible levels.[16] It is also noted that a draft liaison letter was prepared to send to ICAO requesting its participation in future 1994 ITU-R meetings.[17] Information on operating and planned systems operating in the ARNS allocations was also requested. The results of the meetings will be used as inputs to the Conference Preparatory Meeting in March 1995 in preparation for the World Radiocommunication Conference in the fall of 1995.

In summary, based upon the analysis presented here and at TG 4/5, it appears that MSS feeder uplinks can share the 5000-5250 MHz band. Methods to coordinate the location of GLOBALSTAR gateways to protect MLS sites has been provided in Attachments 3 and 4.

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16 "Draft Liaison Statement to Task Group 8/3 and Working Party [8B or 8C]," Document 4-5/TEMP/7(Rev.1)-E, 8 June 1994.

17 "Draft Liaison Letter to ICAO," Document 4-5/TEMP/6-E, 7 June 1994.

ATTACHMENTS

No.	Description
1	"Assessment of MES-Induced RFI on Hybrid GPS/GLONASS Aviation Receivers," Revised June 8, 1994, Sat Tech Systems, Inc., Arlington, VA.
2	"Preliminary Draft New Recommendation, Criteria for Sharing Between the Mobile-Satellite (Space-to-Earth) Non-GSO Systems and the Fixed Service in the 2483.5 - 2500 MHz Frequency Band," Document USTG 2-2/2(Rev.1), June 13, 1994.
3	"Study of 5000-5250 MHz Band for a Globalstar Feeder Uplink," June 10, 1994, Comsearch, Reston, VA.
4	"Interference Assessment of MSS Gateway Uplink Transmissions Relative to MLS Airborne Users," June 8, 1994, Sat Tech Systems, Inc., Arlington, VA.